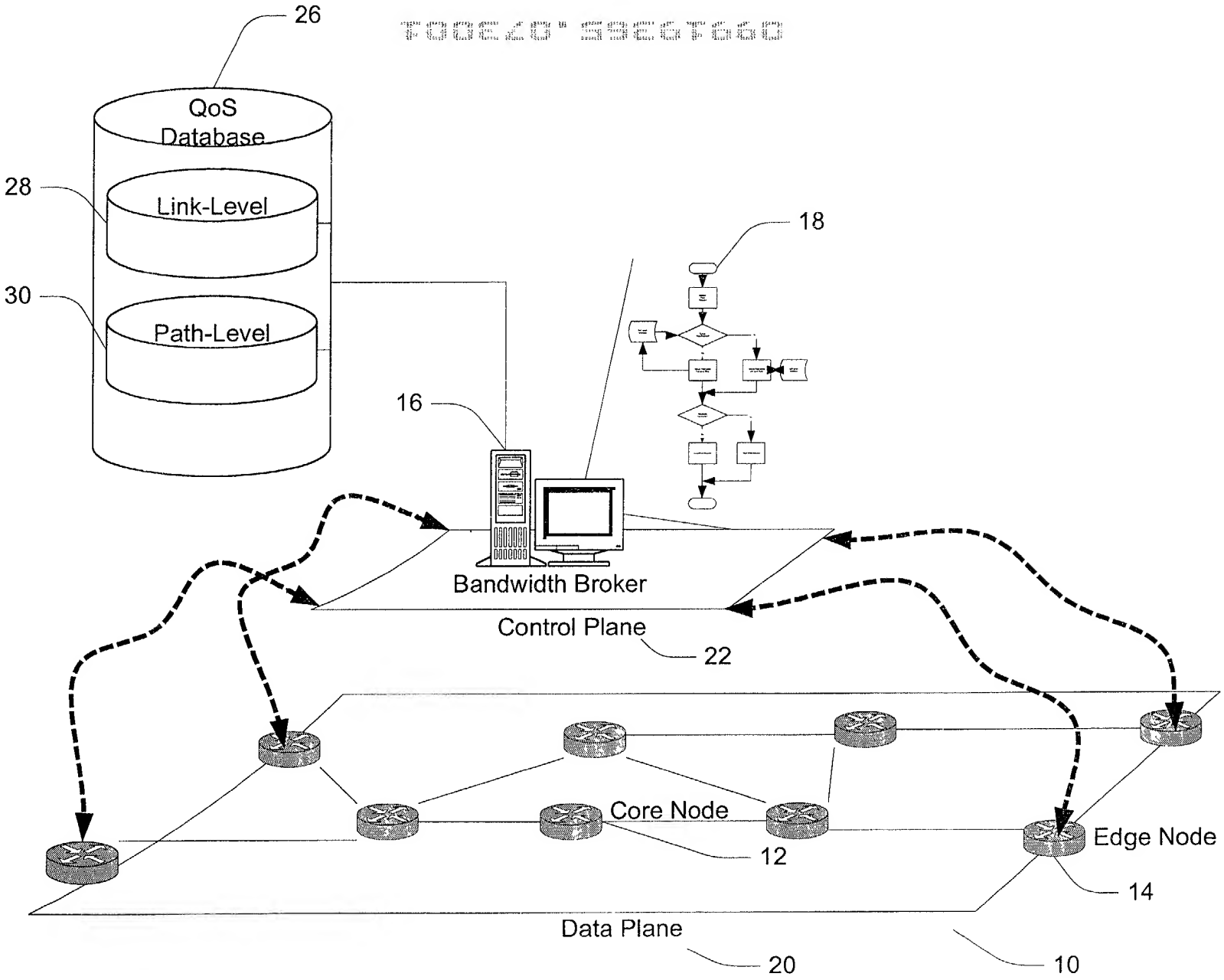
26
QoS Database
28
Link-Level
30
Path-Level
18
16
Bandwidth Broker
Control Plane
22
Core Node
12
Edge Node
14
Data Plane
20
10

FIG. 1

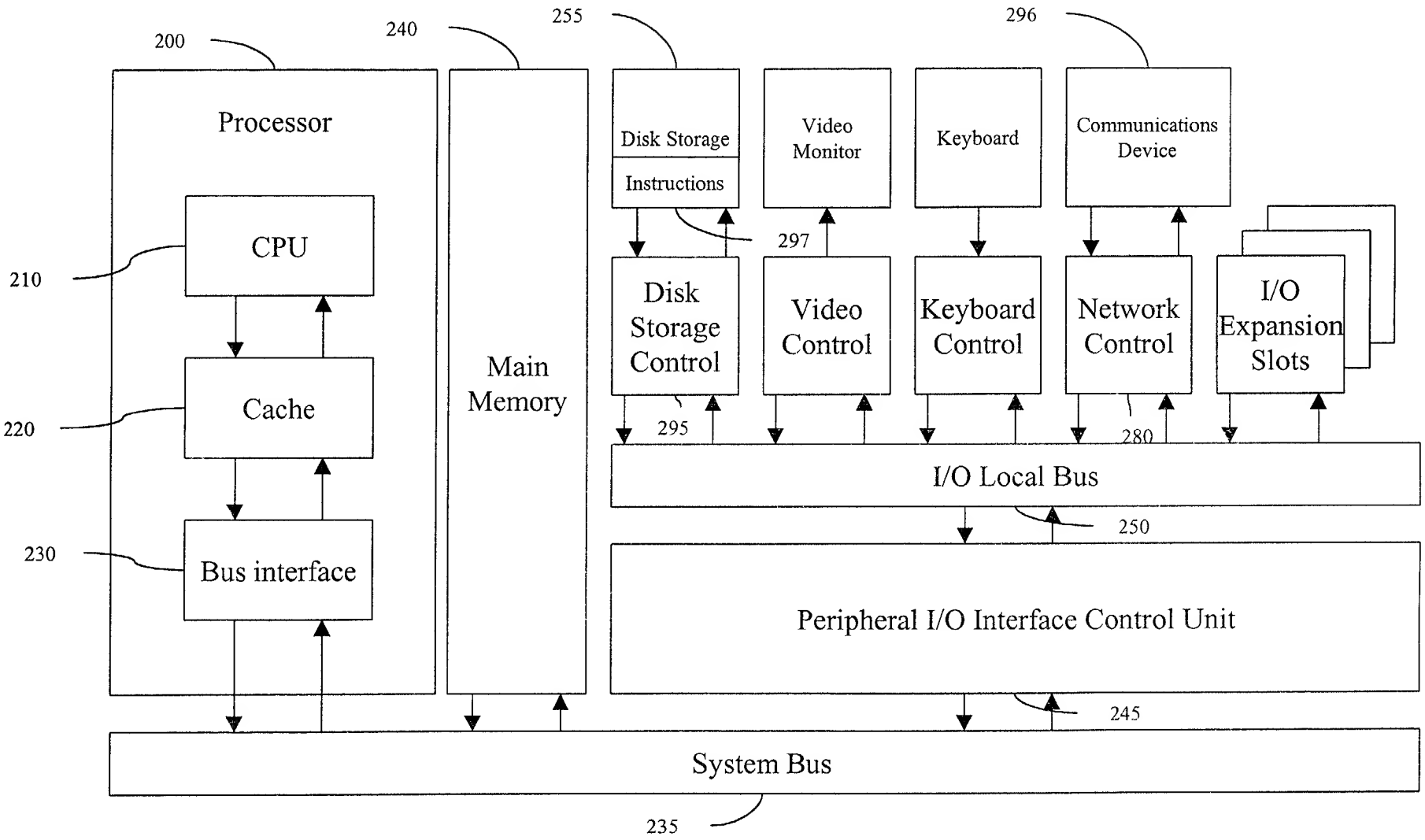

FIG. 2

0. Upon an arrival of a new flow f at a path p:
1. **case 1:** ($op_p == 0$ and $aqb_p \geq r_f$) ~300
2. $R_p \leftarrow R_p + r_f$; accept the flow; return. ~302
3. **case 2:** ($op_p == 0$ and $aqb_p < r_f$) ~304
4. request more quota on all the links l: $l \in p$ ↳306
5. **case 3:** ($op_p > 0$) ~308
6. request bandwidth r_f on all critical links: $l \in cl_p$ ↳310
7. **for** $l \notin cl_p$ ~312
8. if ($aqb_p < r_f$) request more quota ↳314
9. **if** (all requests are granted) ~316
10. update Q_p if more quotas are allocated; ~318
11. $R_p \leftarrow R_p + r_f$; accept the flow; return. ~320
12. **else** reject the flow reservation set-up request. ~322

FIG. 3

Upon a path p requests r_p on a link l:

/* r_p can be a quota or a flow's request rate */

case 1: $(op_l == 0$ and $aq_l < r_p)$ ~400

collect residual bandwidth: $rb_l \leftarrow C_l - \sum_{p:l \in p} R_p$; ~402

if $(rb_l < r_p)$ reject the request; return. ~404

case 2: $(op_l == 1$ and $rb_l < r_p)$ reject the request; return. ~406

/* The request can be honored */

if $(op_l == 0$ and $aq_l < r_p)$ ~408

410 ~ $op_l \leftarrow 1$; /* transition: normal $\rightarrow$ critical */

for $(p' : l \in p')$ ~412

$cl_{p'} \leftarrow cl_{p'} \cup l$; $op_{p'} \leftarrow op_{p'} + 1$; ~414

case 1: $(op_l == 0)$ $aq_l \leftarrow aq_l - 1$ ~416

case 2: $(op_l == 1)$ $rb_l \leftarrow rb_l - r_p$. ~418

FIG. 4

Upon an existing flow f departs on a path p:

$R_p \leftarrow R_p - r_f$; ~ 500

if $(op_p > 0)$ ~ 502

    for $(l \in cl_p)$ ~ 504

506 ~ $rb_l \leftarrow rb_l + r_f$; recompute aq_l; ~ 508

510 ~ **if** $(aq_l \geq 0)$ /* transition: critical $\rightarrow$ normal */

        for $(p' : l \in p')$ ~ 512

            $op_{p'} \leftarrow op_{p'} - 1$; set $Q_{p'}$; ~ 514

            $cl_{p'} \leftarrow cl_{p'} - l$; ~ 516

else if $(op_p == 0$ and p has excess quota$)$ ~ 518

520 ~ $Q_p \leftarrow Q_p - 1$; /* return excess quota */

    for $(l \in p)$ ~ 522

        $aq_l \leftarrow aq_l + 1$; ~ 524

FIG. 5

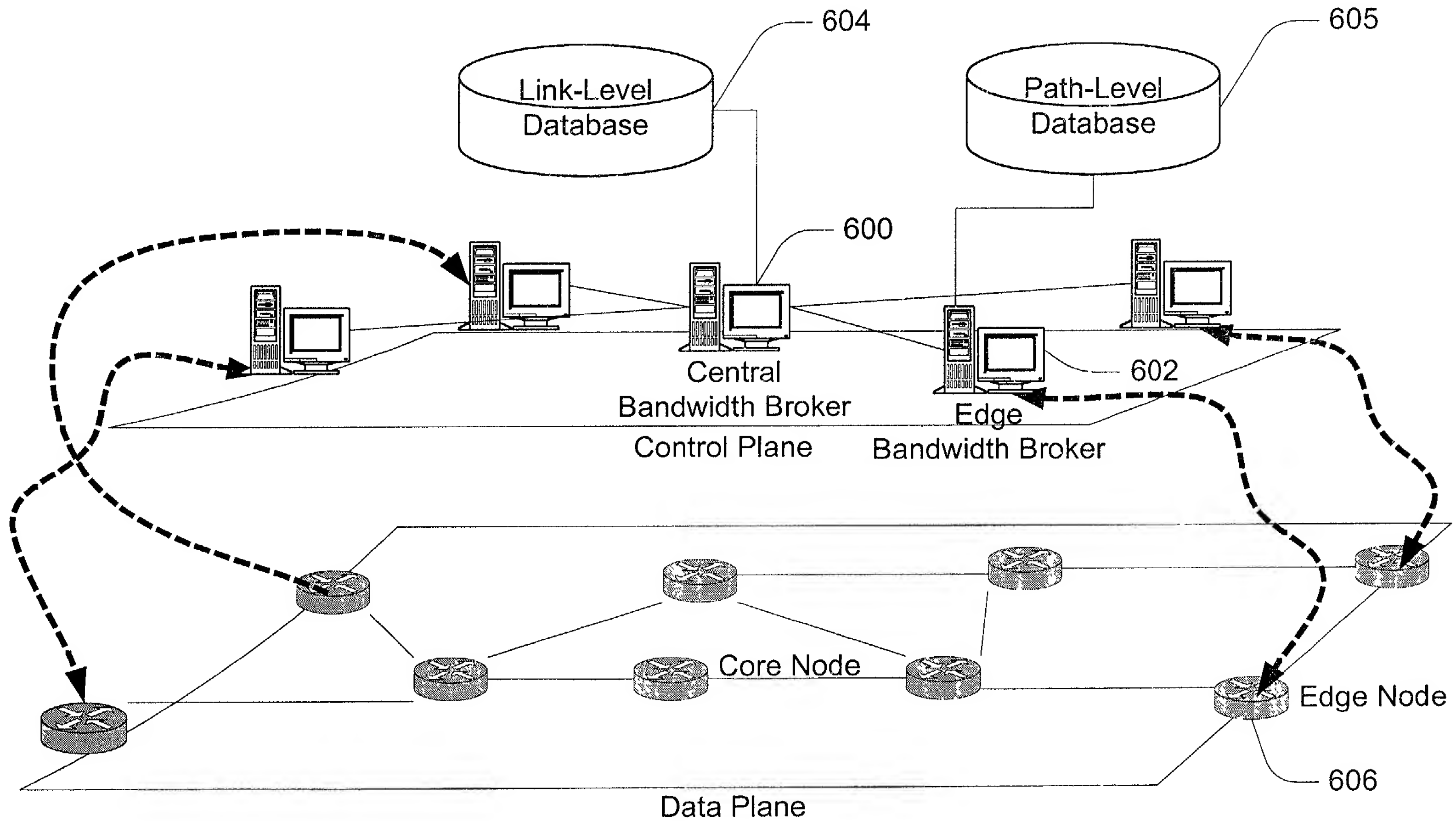
604
605
Link-Level
Database
Path-Level
Database
600
602
Central
Bandwidth Broker
Edge
Bandwidth Broker
Control Plane
Core Node
Edge Node
606
Data Plane

FIG. 6

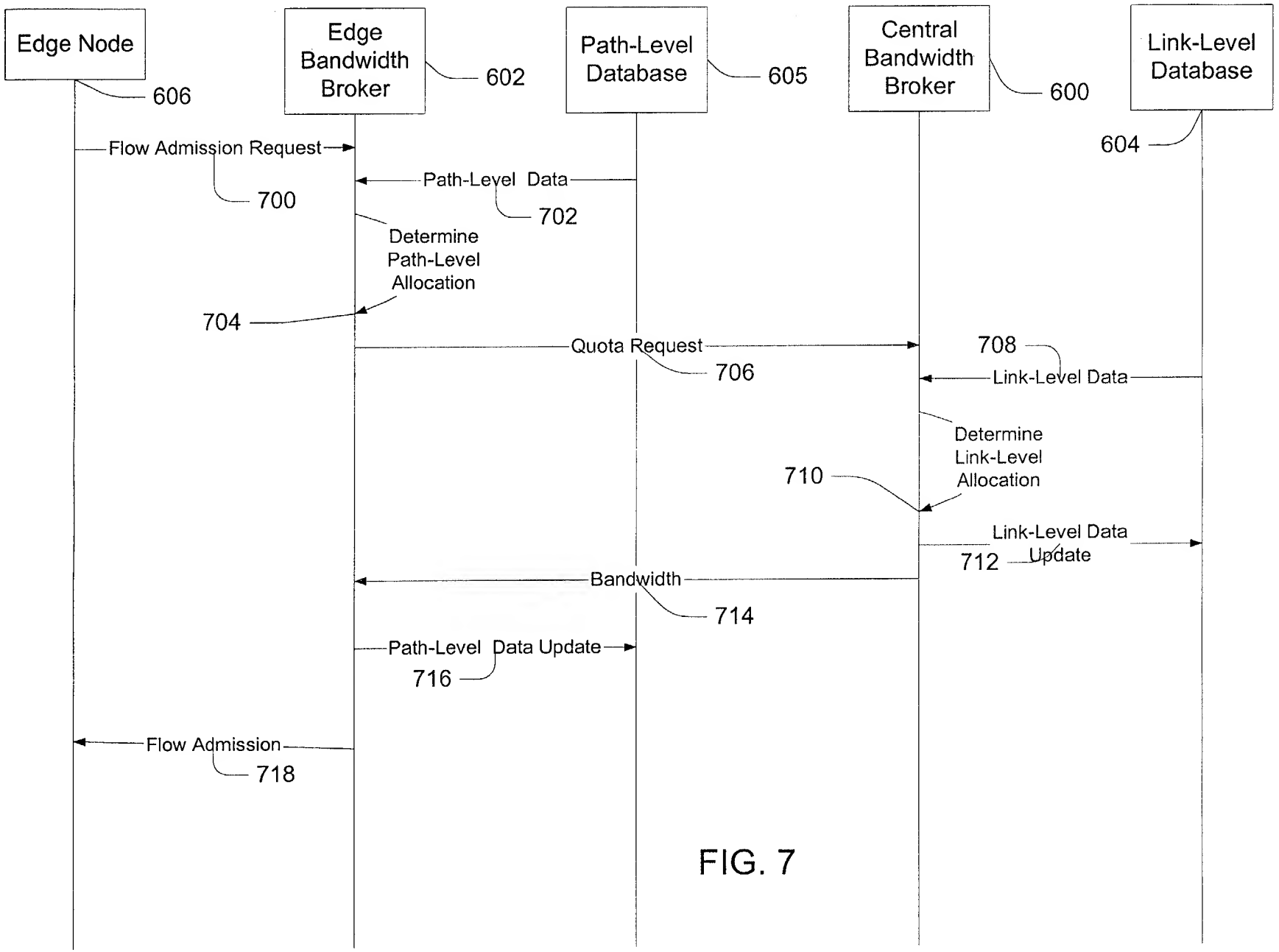
Edge Node
606
Edge Bandwidth Broker
602
Path-Level Database
605
Central Bandwidth Broker
600
Link-Level Database
604
Flow Admission Request
700
Path-Level Data
702
Determine Path-Level Allocation
704
Quota Request
706
708
Link-Level Data
Determine Link-Level Allocation
710
Link-Level Data Update
712
Bandwidth
714
Path-Level Data Update
716
Flow Admission
718

FIG. 7

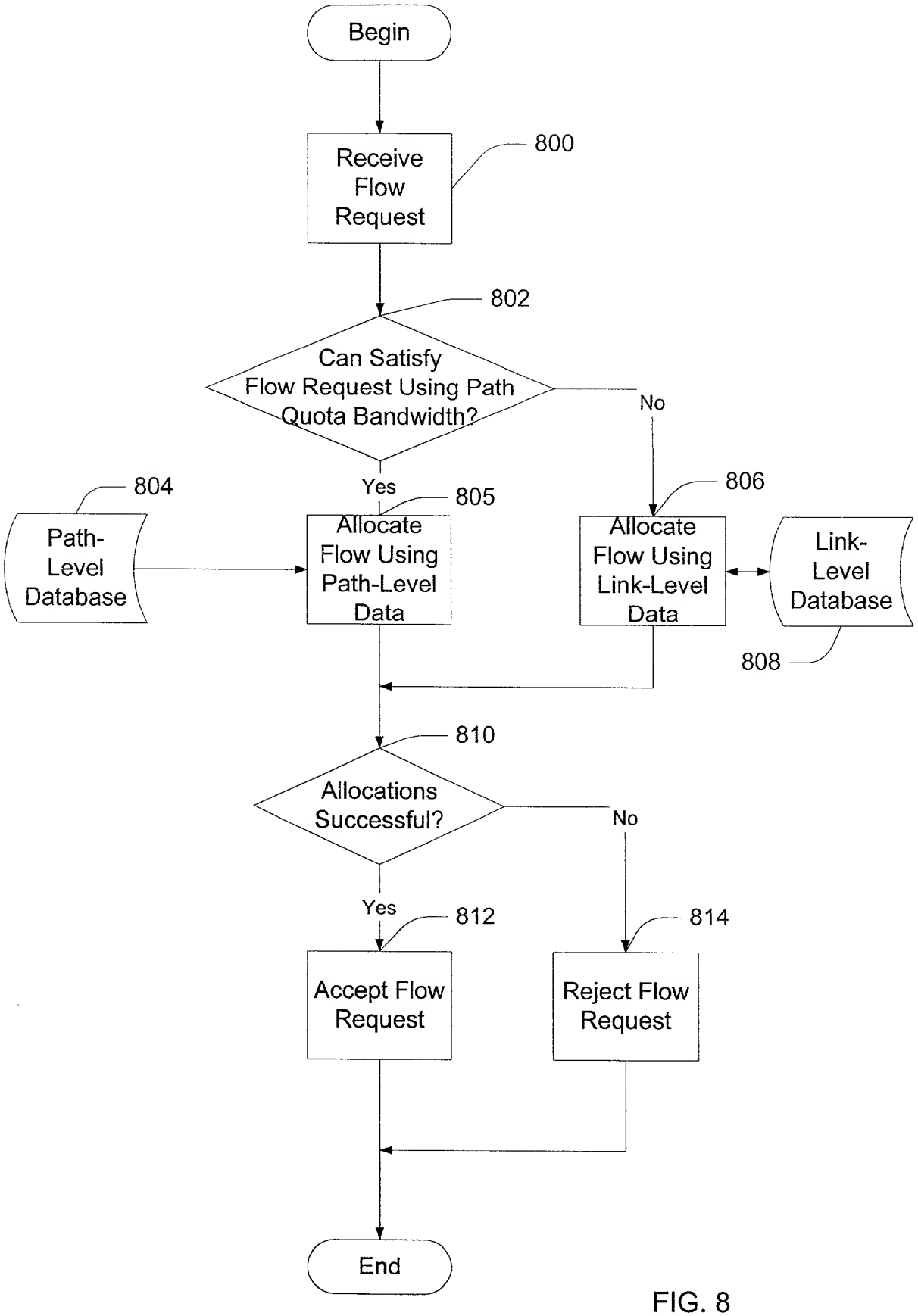
Begin
Receive Flow Request
800
802
Can Satisfy Flow Request Using Path Quota Bandwidth?
No
Yes
804
Path-Level Database
805
Allocate Flow Using Path-Level Data
806
Allocate Flow Using Link-Level Data
Link-Level Database
808
810
Allocations Successful?
No
Yes
812
Accept Flow Request
814
Reject Flow Request
End

FIG. 8